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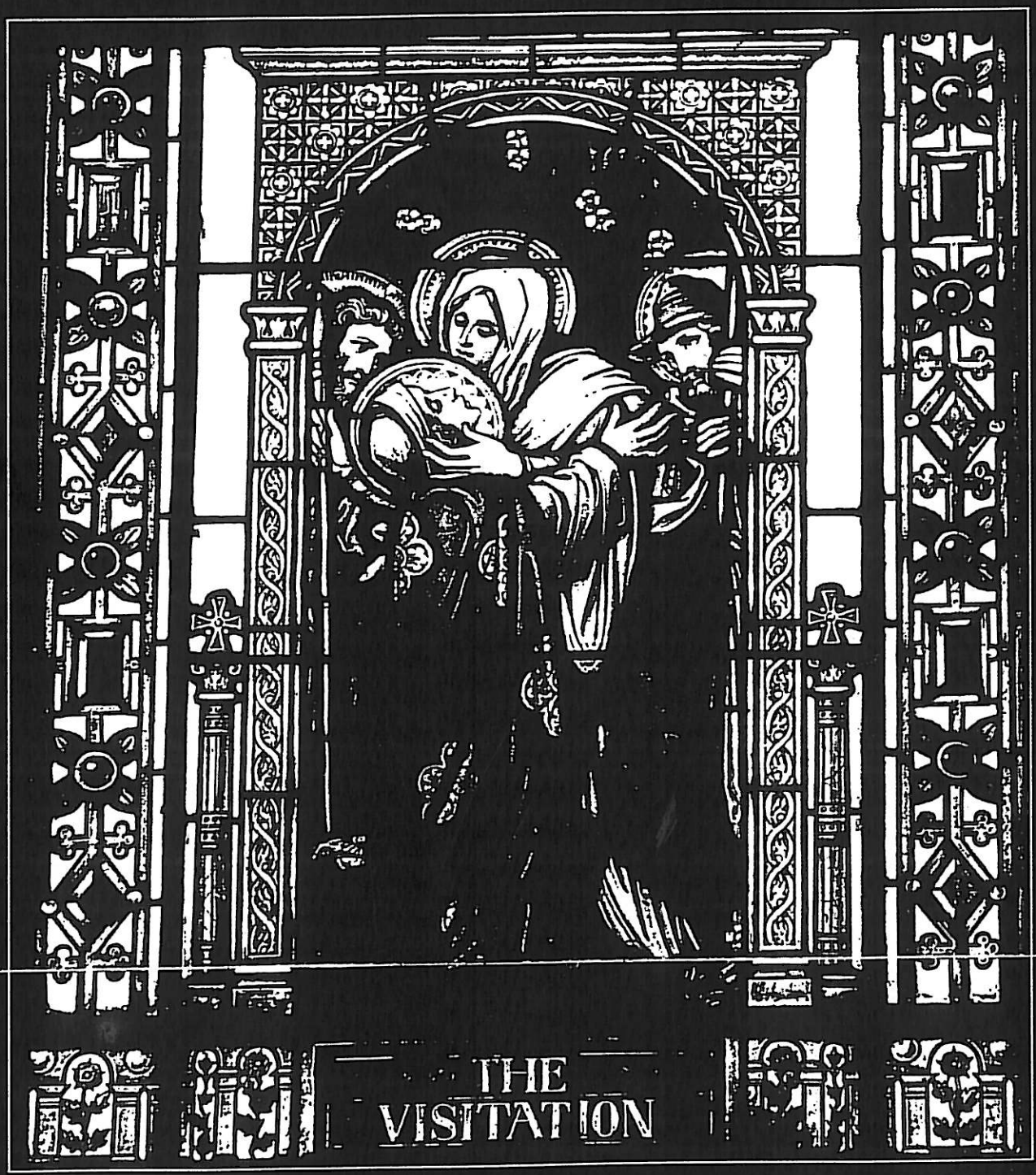

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The History of Protective Glazing

Part Two of a Series on Inspired Partnerships' Study of Protective Glazing

Europe

The Corpus Vitrearum Medii Aevi (CVMA) in Europe records that the earliest known important protective glazing installation for which there is reliable documentation is the application of external diamond-pane leaded glazing over *The Five Sisters* window at York Minster Cathedral in 1861. This medieval window dates from the third quarter of the thirteenth century and contains approximately 1,250 square feet of glass. More protective glazing was installed over the west and east windows in 1862.

The York Minster installations are well documented and therefore an extremely important case study in the history of protective glazing. Records show that the same energy, aesthetic and conservation concerns prevalent in America today were debated over the York Minster protective glazing project a century ago!

Twelve stoves were expected to guarantee a temperature of 50°F at York, but the great expanse of glass made this difficult to achieve. The *Yorkshire Gazette* of June 29, 1861 has an article on the heating of York Minster which stated, "The Dean and Chapter have determined to glaze the outside of *The Five Sisters* window, in the North Transept, with plate glass, to obviate the great draught of cold air through [sic] that expanse of glass; this work will also have the additional advantage that it will protect the beautiful stained glass which in heavy gales from the north is in danger of sustaining considerable damage."

In the *York Herald* on July 17, 1862, a letter to the editor complained about "the covering of *The Five Sisters* and the Great West Window with plate glass which takes away the depth of slay of the mullions and richness of effect,...besides forming a space for dust to lodge in."

Subsequent mention of this early protective glazing installation occurred in 1906 and 1907 in papers concerning the restoration of York Minster. Large plates of "Hartley's rough patent glass" had been used as the 1861 protective glazing. However, these plates had been fastened with iron bars which, due to expansion and contraction, had broken the protective glazing and split the stone mullions. These broken plates were to be replaced with a "complete skin of clear crown glass in diamond quarries, similar to work already done at the Chapter House."[1]

In 1921, the Society for the Protection of Ancient Buildings suggested venting the external glazing over York Minster's windows "especially on the south side, to leave opening in the clear borders of the internal glass at the top and bottom of each light. These openings should be filled with copper wire gauze to keep out insects.... The object of this is to provide ventilation between the glasses and to minimize the effect of condensation produced by changes of temperature in an unventilated space."[2]

Seven years later, the Society changed its opinion to "no protection be put to the glass unless it is very certain that there is real risk of damage happening for want of it."[3] According to Mr. Peter Gibson, the former stained glass conservator at York, "the current English view is to install protective glazing only when necessary and to vent it to either the inside or outside."

During the 1970s, Gibson researched the history of several other English protective glazing installations which are recorded in CVMA newsletters:

1. A church in Cothele, Cornwall, is known to have had protective glazing removed in 1880. It is not known when the protective glazing was installed, but the quarries produced a diamond-shaped corrosion pattern on the outside of the medieval window. The 1480 window was possibly "altered" between 1535 and 1540. Unfortunately, this building was no longer in existence when the CVMA printed this information.[4]

2. The William Peckitt Commission Book at the York City Art Gallery contains an entry which refers to glazing on a William Peckitt window at Audley End in Essex. The entry, dated March 1782, records the purchase of nine panes of strong glass for fixing behind the painted glass in the frame for the panel made for Sir John Ramsden, High Sheriff at Byram Hall, near Ferrybridge, Yorkshire.[5] Unfortunately, this building had also been demolished. Further investigation of Peckitt's work indicates that he often mounted stained glass in suspended frames; therefore the "strong glass" may have served only to strengthen an autonomous panel rather than to fill the role of "protective glazing" as specified in Inspired Partnerships' study.

3. As initially reported in the *British Society of Master Glass Painters* (#8, 408) communications, the Collins-Martin window at Redbourne had outer glazing in iron frames, set before 1845.

Several other nineteenth-century protective glazing installations were documented elsewhere in Europe and reported by Stefan Oidtmann in his published dissertation entitled *Die Schutzverglasung–eine wirksame Schutzmassnahme gegan die Korrosion an wertvollen Glasmalerien* (December, 1994).

4. The great northeast windows at the Orvieto Cathedral, Orvieto, Italy, were covered with protective glazing sometime between 1826 and 1886. Unfortunately, this nineteenth-century installation is not well documented.

5. In 1897, the windows of the small Romanesque church of Lindena (Mark Brandenburg, Germany) were protectively glazed by Dr. H. Oidtmann of Linnich, Germany; the secondary glass was probably installed to protect the window from environmental deterioration.

6. Gabriel Mayer of Franz Mayer'sche Hofkunstanstalt, Munich recalled his father and grandfather mentioning–though he has no documentary evidence since the company records were destroyed in 1944–that nineteenth-century Mayer & Co. and F.X. Zettler (Munich) installations sometimes included large sheets of clear glass for protective purposes.

Given the abundance of stained glass in Europe and the few protective glazing installations recorded, it is readily apparent that the usage of protective glazing during the nineteenth century in Europe can only be described as rare at best.

Its limited use continued until World War Two. Then the perceived value of protective glazing changed drastically. For most of their history, the major cathedrals throughout Europe had established restoration programs, but few had pressing concerns regarding the deterioration of stained glass from atmospheric pollution and moisture. When these great windows were systematically removed for protection from aerial bombing, a unique opportunity to document them arose. Upon reinstallation, the resulting photo survey showed enormous damage to the paint and glass caused by damp storage below ground. As a result of this new awareness, many windows such as those at Cologne, Regensberg and Munich were automatically covered with protective glazing upon reinstallation after the war.

Further studies of medieval glass corrosion caused by acid rain since World War Two have strongly influenced the Europeans to cover their windows with protective glazing. In Germany, protective glazing became common with the repair and restoration of churches since the mid 1950s. Since then, protective glazing has become common throughout Central Europe and in Austria as well as the Netherlands. Gabriel Mayer, a principal of the Franz Mayer'sche Hofkunstanstalt, Munich, concurred with this observation and noted that his company reinstalled many windows with protective isothermal glazing in Germany in the 1950s. Most of these installations were reportedly vented.

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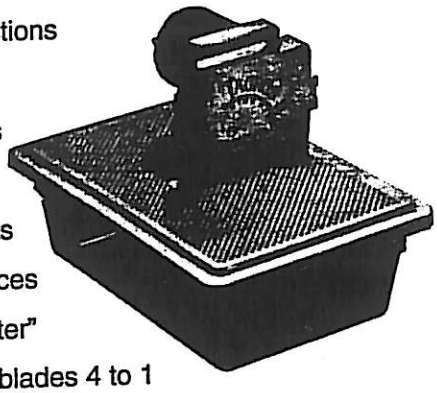

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The European studios from Hungary and England which responded to Inspired Partnerships' survey questionnaire indicated that they promote the use of protective glazing only under specific conditions. France has only recently begun to use protective glazing. Considerable scientific study of European protective glazing installations and their effect on stained glass–particularly medieval glass–has been undertaken since World War Two.

United States

Stained glass was installed on a very limited basis in America before the 1830s and was not commonly used until the 1860s. Prior to the 1860s, most of the stained glass in the U.S. was imported from England, Germany, Holland, France and other European countries. Imported plate glass was available in America by the late 1830s, but it was expensive. As in Europe, the use of protective glazing in the United States during the nine-

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teenth century was extremely rare. Additional "strong glass" to fill a window opening with a second layer could not be justified when the stained glass already served to keep the weather out. Glass-making technology in the U.S. evolved throughout the mid-nineteenth century, and eventually inexpensive domestic plate glass was available for use as protective glazing.

Several attempts to manufacture plate glass in the U.S. during the 1850s ended in failure. The first truly successful plate glass enterprise, the New York Plate Glass Company, was not established until 1880 in Creighton, Pennsylvania. The company changed its name to the Pittsburgh Plate Glass Company in 1883.[6]

Although defined as an infant industry in 1879, new technology reduced manufacturing costs; the cost to the consumer of plate glass dropped by 50% between 1879 and 1884.[7]

As American ingenuity spread through the glass industry, the domestic output of polished plate rose to 82% by 1890, while rough plate (more commonly used for protective glazing) rose to 97%.[8] Further, domestic plate-glass production tripled, from 1,055,224 square feet in 1890 to 3,342,573 square feet in 1919.[9] This growth is attributable to technological improvements in plate glass manufacturing. For example, a United States patent for tempered glass was issued on December 15, 1874; tempered glass is stronger and more difficult to fracture than ordinary glass.

In 1897, the Marsh Plate Glass Company in Floreffe, Pennsylvania, installed the first continuous lehr for annealing plate glass, reducing the annealing time from three days to three hours.[10] With these developments and others, American machinery was being sought abroad. Electric-powered grinders and polishers also played a significant role by 1900.

However, until the First World War, plate glass was produced almost entirely by the "casting" method, in both the U.S. and Europe. Glass was melted in regenerative pot furnaces. The pots were removed from the furnaces by a crane, skimmed and partly inverted over a flat, cast-iron casting table, which was covered with fine sand to prevent the glass from sticking or chilling too quickly. The molten glass was poured in a continuous stream just ahead of an enormous water-cooled cast-iron roller. The roller was lifted and the glass removed to a series of lehrs, yielding rough-rolled glass.

Polishing the rough-rolled glass was costly. Various pieces of rough glass were fitted onto a plaster bed, on a circular table up to 30 feet in diameter. The table was transferred to a grinding frame, where large iron disks, supporting smaller iron disks, were spun on the sheets with increasing pressure. First coarse sand and water, then finer sand and finally emery and water were fed to the grinding surfaces, gradually wearing away irregularities. The process took approximately one hour. The table was used again for polishing, using felt wheels, a finer abrasive rouge (iron oxide) and water. Upon completion of the grinding and polishing, the rough plate was half its original thickness.

Prior to 1889, it took nearly 10 days to produce a piece of polished plate glass from the raw materials. Max Bicheroux of Germany developed a new type of rolling machine shortly after the First World War. His machine produced sheets of predetermined length in a semicontinuous process. In 1922, U.S. automaker Henry Ford introduced continuous rolling in the manufacture of automobile glass and revolutionized the American glass industry—soon to be the largest producer of plate glass in the world.

Making the blank, grinding and polishing became an automatic and continuous process, like an assembly line. This process was adapted by Libby Owens Ford Glass Co. in 1925. Using the pot-casting and continuous-rolling method of 1922, it took 54 hours to produce plate glass; the semicontinuous method of 1925 further cut production time to only 22 hours! The introduction of ever-larger sheets of glass produced with increasing technical efficiency and lower costs made double glazing more and more common.

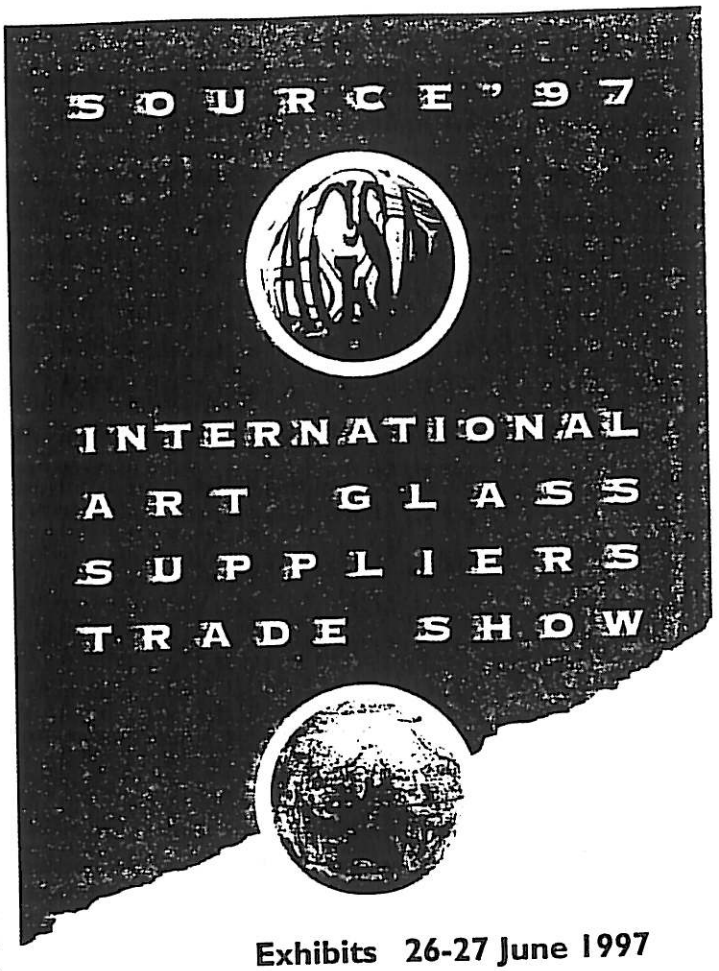
The American development of plated opalescent ndows by John LaFarge, Louis Comfort Tiffany and hers led to some of the earliest use of protective glaz- g in the United States. Plated opalescent windows con- ting of several layers of glass inherently called for the e of large outer glass plates to keep the window inter- aces free of dirt and moisture. The exterior plate(s), tegral with the window, effectively served as protective azing.

Many plated windows were installed throughout the untry by the early 1890s, but most are not representa- e of the typical protective glazing installation. Within decade, plated windows were sometimes covered with full back-plate of rough (unpolished) or ribbed plate ass. A recent restoration of 1902 plated windows found Old St. Paul's in Baltimore and made by Maitland rmstrong (a Tiffany colleague) appears to have had riginal "textured" protective glazing. This exterior glaz- g was set in an iron frame and bolted to the angle-iron sh holding the stained glass.[11]

There are reports of domestic ribbed plate glass stalled over German imports from the late nineteenth ntury in the Northeast. However, Theodore C. Von erichten, whose grandfather founded Von Gerichten rt Glass Company (Columbus, OH) in 1893, does not call any practice of installing protective glazing over eir domestic windows or those they imported from lunich, Germany. A search through hundreds of nine- enth-century and early twentieth-century photos of hicago churches uncovered no examples of protective lazing over stained glass.

Only three examples of protective glazing in the nited States prior to 1900 have been substantiated by he Inspired Partnerships study. All three represent the sual concept of protective glazing as a separate layer ver traditional (single layer) stained glass. St. Thomas piscopal Church in Taunton, Massachusetts was severe- y damaged by fire in January 1898. An article in the arish magazine in September 1898 listed repairs and mprovements as a result of the fire and noted "...the ose window guarded against leaks by storm sash." The econd Church of Christ in New York City has original rotective glazing from 1899. The St. Vincent de Paul hurch in Chicago has 3/16" thick rough plate glass set in opper t-bars from 1897. Stained glass windows by Mayer & Company of Munich were inserted behind the tempo- ary glazing sometime before 1900.

A number of documented protective glazing instal- ations have been identified from the first quarter of the wentieth century. The art glass at Wellington Avenue Congregational Church, constructed in a bustling Chicago neighborhood in 1910, was installed in hollow- core steel window frames behind wire safety glass. Crammed into a small site on a residential block, the use of protective glazing may have been motivated by build-



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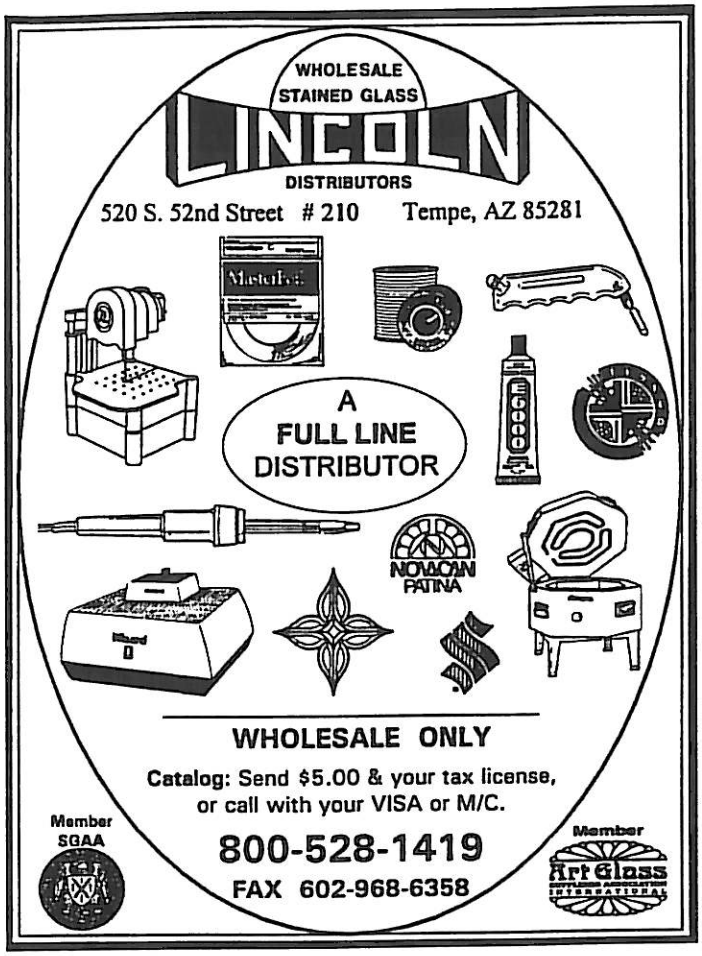

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ing codes designed to limit the spread of fire rather than any concern for "protecting" the simple art glass.

Plated Munich-style windows at St. Mary's Church in Beaverville, Illinois, were covered with plate glass provided by the Pittsburgh Plate Glass Company in 1911. Today, several types of plate glass, mostly ribbed, are found on the church.

The C.J. Connick Collection at the Boston Public Library provides valuable insight on how one of the most prolific American stained glass studios, Connick Associates, handled the use of protective glazing in the early twentieth century. Although the studio was formed in 1912, protective glazing was not mentioned in company contracts during the first few years in business. However, the Collection contains dozens of references to protective glazing installations starting around 1920, when Hyde Park Baptist (Union) Church in Chicago paid an extra $100 for protection glass in an outside frame. A mausoleum in Rosehill Cemetery, Chicago, was to have "protection glass furnished by the donor...installed by Temple Art Glass Company," an indication that protective glazing was sometimes subcontracted to local glaziers. By the late 1920s, job records in the Connick Collection often indicate whether "protection glass" was ordered or not.

Other early American protective glazing installations include a stained glass window by Willet Studios in Calvary Church, Chestnut Hill, Pennsylvania, that was covered with plate glass for $250 in 1915. The Chapel of St. James of Quigley Seminary in Chicago has ribbed plate glass protective glazing from 1917, while Buena Memorial Presbyterian Church in Chicago has leaded diamond-pane protective glazing from 1922. Both of these installations, as apparent with many others around the country, became a protective layer by default. Once available, stained glass was simply inserted behind external glass rather than replacing it.

An August 1925 parish monthly from St. Mary of the Immaculate Conception of Michigan City, Indiana, states that the imported F.X. Zettler windows installed from 1925-1927 "will all be protected against the weather by storm glass." Protective glazing was a frequent option by 1925, the year Mr. Henry Hunt spoke on "Setting Storm and Leaded Glass" at the National Ornamental Glass Manufacturers Association conference held in Pittsburgh.

Protective Glazing and the Building Industry

As protective glazing became common to the stained glass industry, it began to attract attention from the architectural community and manufacturers. *Good Practice in Construction: Part II*, published in 1925 by The Pencil Points Library, illustrates a leaded glass window in a stone wall with double glazing and notes "extra glass affords protection to the expensive leaded art glass from the weather and possible exterior damage." No venting of the air space is indicated.

The same reference also describes a "double, double type" ventilator. The manufacturer, J. Sussman, Inc. has been making steel windows for churches since 1906, and Jack Sussman believes his father, the company founder, made double-glazed ventilators from the start.

A 1926-27 Sweet's Architectural Catalog listing for The Philadelphia Supplies Company, Inc., has sectional views of a double glazed window with a 3/4" air space between the storm and leaded glass, and "double, double" ventilators.

Stained glass has always served a specialized market, complicating the research for double glazing. The Philadelphia Supplies Co. was the only one out of 15 steel window companies listed in the 1926-27 Sweet's to promote double-glazing. Most of the manufacturers targeted the industrial market, which had little need for protective glazing. The Great Depression brought church construction to its knees, which further limited the demand for items such as stained glass. Although protective glazing was becoming more readily accepted in the U.S., it still remained the exception rather than the rule before World War Two.

In residential construction, the notion of glass storm windows as "double glazing" did not become popular until after the Civil War. Storm sashes were regularly available in sash and blind company catalogs by 1900. The catalogs tout the benefits of storm windows in terms of energy savings, greater comfort and the ability to prevent illness. Noelke-Lyon Manufacturing Company asked, "Why should anyone be without these items (storms) that easily save their cost in a few seasons?"[12]

Early residential storm windows were often installed on hooks or hinges for easy seasonal installation and removal; they usually had elliptical holes on the bottom rail that served as hand-holes and vents during unseasonably warm weather. By the 1920s, extruded rubber weatherstripping led to double-insulated steel casement windows, featured in the 1924 *Audel's Carpenters and Builders Guides*. However, these windows had limited success, and single-pane steel windows remained prevalent until the 1950s.

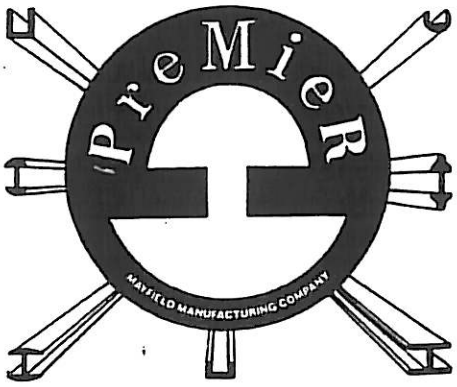
The architectural firm of Keck & Keck (Chicago) designed the first thermalpane window as a sealed unit in 1935 to alleviate condensation and dirt. By 1941, double-hung and casement thermalpane windows were commercially available in wood or steel.

"By building a wall of captive air, the inner pane is kept comparatively warm even though the outer pane may be very cold. This greatly decreases the heat transmission through the window and simultaneously eliminates foggy windows and dripping sills," C.J. Phillips reported in *Glass: The Miracle Maker*. Energy tests at that time indicated a savings of 23% to 36% for double glazing. Further studies in the *Architectural Forum* and *American Builder* revealed that in many cases "double glass insulation pays for itself in two years or less, in fuel savings alone."[13]

These studies were likely developed for houses with 24-hour occupancy. Without any published concerns for how intermittently-used buildings should be heated, someone reading this in the 1940s might conclude that if double glazing is so effective in terms of energy, it should be used everywhere. Regardless, the value of double-glazing was further advanced during the 1940s in residential and commercial building markets, which traditionally lead the building industry as a whole.

Methods of producing stronger glass evolved in the years leading up to, during and immediately after World War II. Even leaded glass was not spared, as dalle de verre was developed in France in 1937. Eventually dubbed faceted or slab glass in America, such windows can be more than 1" thick and were originally set in a hard cement matrix (now epoxy). Generally less expensive and much stronger than leaded glass, slab glass has grown in popularity since its introduction in the U.S. in the 1940s. Ironically, despite its wall-like strength, protective glazing has been installed in recent years over several slab-glass installations in the United States.

An advertisement for tempered, polished glass from Libby Owens Ford appears in the 1950 Sweet's catalog. Sold under the trade name of Tuf-flex®, it was made by a process of reheating and sudden cooling, yielding an outer glass surface in a state of high compression, which is highly resistant to breakage. Glass treated in this way is three to five times stronger than regular plate glass in sustaining wind loads, three times more resistant to thermal shock and five to seven times more resistant to impact. Tempered glass, like Tuf-flex®, shatters if cut and must be made to size specifications before it is tempered—a purchasing and scheduling hurdle for glazing contractors looking for greater strength and job-site flexibility.



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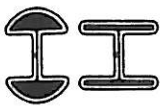

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The 1950s saw the introduction of glass alternatives for protective glazing. Alternatives included translucent fiberglass sheets and a barrage of sheet plastics to follow, which greatly simplified protective glazing installations.

More and more window manufacturers recognized the rapidly changing market after World War Two and began designing frames to accommodate double glazing. A terra cotta rose window detail by the Architectural Terra Cotta Institute from around 1950 shows two preformed glazing grooves, one for stained glass and the other for storm glazing. A National Metallic Sash Company brochure illustrates a window sash for double glazing manufactured in brass, bronze, aluminum, steel and stainless steel.

According to a company brochure, the Twin Beam Corp. was incorporated in 1925, but its "twin beam" section was not designed until 1950 and then specifically for churches. The Series 100 was double glazed and 2½" deep. The outer glass is plain, the inner glass leaded. "The system is considered highly protective, highly efficient in reducing heating and air-conditioning loads, in reducing transmission of street noise."

A company brochure for J. Sussman's steel windows from the early 1950s shows double glazing in a stone-and-wood setting. A later catalog illustrates the 300 Series, an aluminum double-glazed church window that Sussman has produced since 1959. The 300 Series "is specially designed to receive protective glass on the exterior and stained glass on the interior. This 'Double Glazing' protects the stained glass from vandalism while also insulating from the heat and cold and reduces outside noise infiltration. The insurance and fuel costs can be substantially lower...either glass can be installed without disturbing the other. The exterior glass can be installed at time of erection to close up the building and the stained glass installed at a later date at the churches' own convenience." None of these manufacturers vented the air space.

The commercial availability of sheet acrylics drastically changed the glazing industry and created new opportunities for less-skilled contractors to enter the protective glazing business, increasing competition and sales. Dominating the protective glazing market during the 1960s and early 1970s, the research of acrylic actually dates back to Otto Rohm, who initially investigated the polymerization of acrylic for his doctorate in 1901! However, he did not pick up this research again until 1920, seeking to expand his business in the race against similar work in progress at Imperial Chemical Industries (ICI)in Britain and at Du Pont Laboratories in the U.S. Eight years later, Rohm and his associate Walter Bauer developed a polymethyl acrylate interlayer for safety glass that was marketed by a U.S. firm as Plexigum® in 1931. It was better than celluloid (which yellowed) or cellulose acetate, which becomes brittle at low temperatures. However, it could not compete with polyvinyl butyl, introduced in 1936.[14]

Bauer and Rohm continued experimenting and came up with polymethyl methacrylate, a transparent glass-like substance that could be sawn, machined and cast in sheets. They also discovered that polymerization occurred through exposure to light. Instead of cementing two sheets of glass together as with Plexigum, this polymer separated cleanly from the glass in a strong sheet. The new material became known as Plexiglas® and was commercially available in both Germany and the U.S. in 1936.[15]

Du Pont and ICI meanwhile continued research, focusing on casting and molding acrylic into rods, tubes and blocks. With the commercial introduction of acrylics coming and a joint desire to forestall patent litigation, all three companies agreed to an intricate set of cross-licensing agreements in 1936. First, Rohm announced Plexiglas®, followed by ICI in Great Britain with Perspex® and then Du Pont with Pontalite®, called "a new, water-clear plastic, strong as glass, flexible and non-shattering."[16]

Bauer and Rohm's American sister firm, Rohm and Haas, obtained a license for casting acrylic sheet from the German firm in late 1935 and in January 1936 sent Donald S. Fredrick to Darmstadt for two months to

familiarize him with acrylic-sheet manufacture and fabrication. Fredrick then demonstrated Plexiglas* to the U.S. Army Air Corps and won a decree stating that polymethyl methacrylate was the only plastic sheet material approved for use in military planes. Du Pont did not know exactly how Rohm was casting large acrylic sheets until 1939, when a licensing agreement granted Du Pont half the annual sheet capacity of Rohm and Haas. The name Plexiglas* implied a flexible improvement over glass while Du Pont's Pontalite* did not. Shortly after its introduction, Du Pont dropped the name Pontalite* in favor of the name Lucite*. Soon thereafter, Du Pont controlled the U.S. acrylic market.[17]

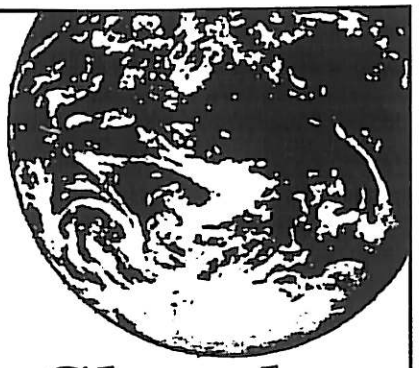
Laminated glass incorporates both glass and plastic technology. Developed by Bernard Carsten in 1912, it was manufactured by the Progressive Windshield Company of Chicago (later the Chicago Bullet Proof Equipment Company). The Prohibition era accelerated the need for laminated glass, and it was used by police and banks, as well as in some get-away-cars! Chicago Bullet Proof Equipment Company's specialized line of glazing materials protected people from people; it also protected stained glass from people and from natural disasters. Variations of their high-impact material found a home in hurricane-prone areas such as Florida.

Laminated glass is comprised of a tough, flexible interlayer of plastic sandwiched between two or more sections of glass. According to the Glass Association of North America, laminated glass is made by one of three methods today: plasticized polyvinyl butyral (PVB) sheet, which includes Monsanto's Safelex*, Du Pont's Butacite* and Sekisui's S-Lec*; aliphatic urethane (AU) sheet, which includes JPS Elastomerics Stevens* and Deerfield Urethane's Duraflex*; and ultraviolet-cured acrylic resin (UV-CAR), which includes UCB Radcure's Uvekol*.[18] PVB and AU are placed between two or more lites of glass and bonded by heat and pressure. UV-CAR is a liquid laminating system which crosslinks and bonds to both plastic and glass when exposed to ultraviolet light.

In the late 1980s, Du Pont began to mass-market a Butacite* family of advanced composite glazing products with names such as Du Pont Sentry Glas*, Spallshield* and Butacite* interlayer. According to company trade literature, these glazing types offer the same natural light and viewing characteristics of conventional window glass while being able to withstand the impact of a nine-pound 2"x4" traveling at 34 mph or a 26-pound cinder block at 40 mph. Each of these glazing products features a Butacite* PVB interlayer.

Softer, less brittle and stronger than acrylics, polycarbonates were first developed as a resin in the 1960s and manufactured in sheets in 1970 by General Electric Plastics. GE dubbed their product Lexan*, and its popularity and trade name has become so widespread that in the protective glazing industry many consumers and installers generically refer to any plastic sheet material as "lexan" regardless of the actual product.

Although it weighs about the same as acrylic products, the impact resistance of Lexan* is said to be 30 times stronger than acrylic and 250 times greater than standard glass. Upon installation, the clarity of Lexan® is almost that of glass, but it will yellow and haze over a few years. GE continues to develop new variations such as Lexan XL*, which is coated with an acrylic non-yellowing ultra-violet protective surface. It has been subjected to a three-year exposure test in which it was observed to bleach, resulting in a clearer product with slightly higher light transmission and less yellowing. Lexan MR5* is coated with a silicon abrasion-resistant coating called Margard* to reduce scratching. Polycarbonates have been the most preva-



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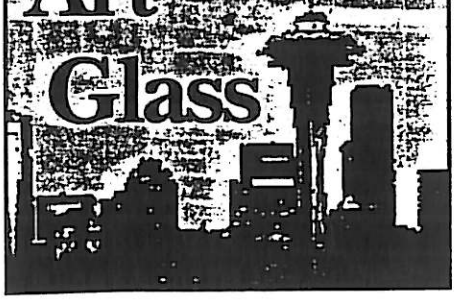

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lent material used for protective glazing since the mid-1970s, but chronic aesthetic and technical problems are changing the perception of this incredibly strong material.

Today, protective glazing technology has evolved to the point of triple-glazing! The concept of triple-glazing for stained glass was developed in the wake of triple-glazing for residential and commercial windows by the mid-1980s. Triple-glazed windows were developed in response to increasing demands for energy performance, an important concern for buildings and spaces occupied for long periods of time.

Some consider triple-glazing the "cutting edge" of protective glazing. The Mormon Church, considered to be among the best builders of energy-efficient churches, is reportedly specifying triple-glazed window units on all new Mormon churches. J. Sussman currently offers two triple-glazed window types, the 5200 Series and the 5600 Series. The 5600 Series is incorporated into a 3½" thermally broken frame and "can accommodate protective insulated glass with another ⅜" minimum air space between the art glass to maximize the protection and insulation of the art glass.... The separation of art glass and protective glass is achieved by a channel that is an integral part of the extrusion (not an add-on piece). This channel acts as a condensation gutter and helps prevent air and water infiltration."

Custom made triple-glazed units are also being fabricated today in which the stained glass is sandwiched between (not behind) outer glass layers.

About the Inspired Partnerships Study

Inspired Partnerships, a not-for-profit organization based in Chicago, IL, received a $34,320 grant from the National Preservation Center in October 1994 to investigate the virtues and liabilities of various protective glazing installations over stained glass. The study was conducted over an 18-month period from October 1994 to April 1996 and addresses energy, security, sound and light transmission and aesthetic and conservation issues surrounding the use of protective glazing. Although some aspects of this research are applicable to all protective glazing, the study concentrated on the virtues and problems associated with installations over stained glass in houses of worship. Churches and temples have specific energy, maintenance and security concerns which tend to be unique to their function, management and operation.

"Protective glazing" (PG) is defined as a secondary layer of sheet glass or plastic on the exterior of a stained glass window. PG is also described as "storm," "double," "outer" and "secondary" glazing, and these terms are used interchangeably throughout the study. "Stained glass," for the purpose of this study, pertains to all types of leaded glass. In addition to research, the study included: 1) a stained glass studio survey; 2) a field survey of 100 protective glazing installations in four different U.S. regions; 3) *in situ* testing of two protective glazing installations; 4) an energy model of an intermittently heated building and 5) the alteration of 10 protective glazing installations.

Inspired Partnerships first assembled a Protective Glazing Advisory Committee that included the following people: Rolf Achilles, Art & Industrial Historian (Chicago, IL); Arthur J. Femenella, Stained Glass Consultant with Femenella & Associates (Annandale, NJ); Dr. Mark Gilberg, Research Scientist with the National Preservation Center of the National Parks Service; (Natchitoches, LA), Thomas Harboe, Director of Preservation with McClier (Chicago, IL); Barbara Krueger, Stained Glass Artist and Historian (Hartland, MI); Richard Pieper, Restoration Consultant (New York, NY); Andrew Rudin, Energy Consultant (Melrose Park, PA); Dr. Wayne Simon, P.E. (Evergreen, CO); and Neal A. Vogel, Director of Technical Services with Inspired Partnerships (Chicago, IL). Several Committee members served as authors and editors of the final report as well.

Susan Reilly, P.E. of EnerModal Engineering, Inc., was also commissioned by the National Preservation Center to report on the energy value of protective glazing over stained glass. Many other people provided assistance for this study but are far too numerous to mention. However, those who deserve special recognition include: Susanna Aulbach, German Translator; Matthew Bellocchio, Roche Organ Company; Chris Botti and Mike Smoucha, Botti Studio of Architectural Arts; Janice H. Chadbourne, Curator of Fine Arts, Boston Public Library; Richard Cieminski, Jon-Lee Art Glass; Marit Eisenbeis and Charles Kiefer, Inspired Partnerships; Betty Kirpatrick, Hermosa Mountain Studio; Gabriel Mayer of Franz Mayer'sche Hofkunstanstalt, Munich, Germany; Virginia Raguin, Holy Cross College; Jack and David Sussman, J. Sussman, Inc.; Susan Tunick, Friends of Terra Cotta; Theodore Von Gerichten; Kirk D. Weaver, Pittsburgh Stained Glass; and David Wixon, Wixon & Associates. Inspired Partnerships would also like to thank the numerous stained glass studios who provided assistance by completing questionnaires and reporting past experiences with protective glazing.